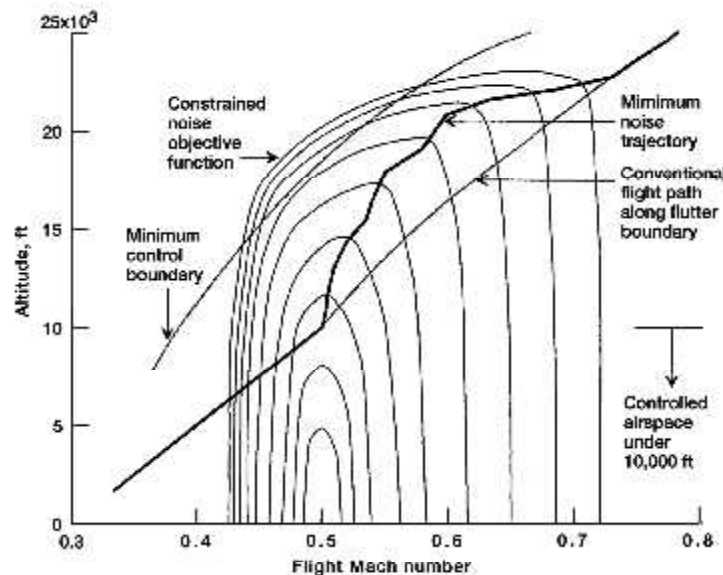


Minimum Climb to Cruise Noise Trajectories Modeled for the High Speed Civil Transport

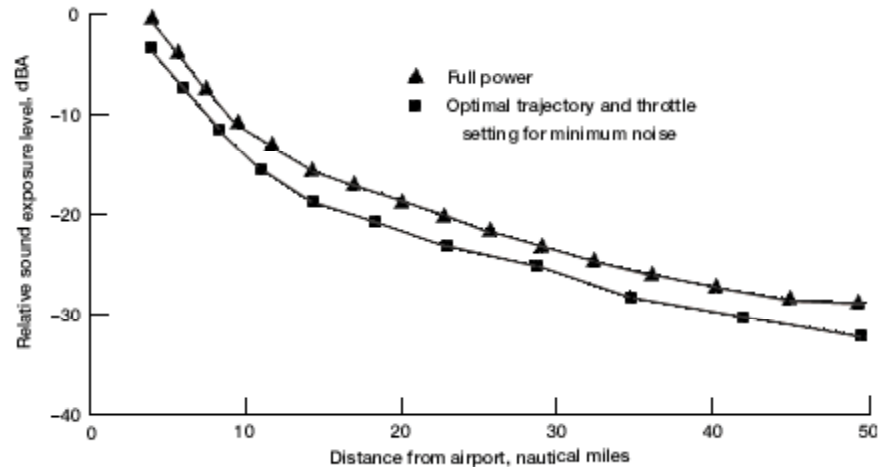
The proposed U.S. High Speed Civil Transport (HSCT) will revolutionize commercial air travel by providing economical supersonic passenger service to destinations worldwide. Unlike the high-bypass turbofan engines that propel today's subsonic airliners, HSCT engines will have much higher jet exhaust speeds. Jet noise, caused by the turbulent mixing of high-speed exhaust with the surrounding air, poses a significant challenge for HSCT engine designers. To resolve this challenge, engineers have designed advanced mixer-ejector nozzles that reduce HSCT jet noise to airport noise certification levels by entraining and mixing large quantities of ambient air with the engines' jet streams. Although this works well during the first several minutes of flight, far away from the airport, as the HSCT gains speed and climbs, poor ejector inlet recovery and ejector ram drag contribute to poor thrust, making it advantageous to turn off the ejector. Doing so prematurely, however, can cause unacceptable noise levels to propagate to the ground, even when the aircraft is many miles from the airport.



Optimized HSCT flight path for minimum noise (not to scale).

This situation lends itself ideally to optimization, where the aircraft trajectory, throttle setting, and ejector setting can be varied (subject to practical aircraft constraints) to minimize the noise propagated to the ground. A method was developed at the NASA Lewis Research Center that employs a variation of the classic energy state approximation: a trajectory analysis technique historically used to minimize climb time or fuel burned in many aircraft problems. To minimize the noise on the ground at any given throttle setting, high aircraft altitudes are desirable; but the HSCT may either climb quickly to high

altitudes using a high, noisy throttle setting or climb more slowly at a lower, quieter throttle setting. An optimizer has been programmed into NASA's existing aircraft and noise analysis codes to balance these options by dynamically choosing the best altitude-velocity path and throttle setting history.



Relative noise at ground level for various trajectories.

The noise level standard, or metric, used in the optimizer should be one that accurately reflects the subjective annoyance levels of ground-based observers under the flight path. A variety of noise metrics are available, many of which are practical for airport-vicinity noise certification. Unlike airport noise, however, the HSCT's climb noise will be characterized by relatively low noise levels, long durations, and low-frequency spectra. The noise metrics used in these calculations are based on the recommendations of researchers at the NASA Langley Research Center, who have correlated the flyover noise annoyance levels of actual laboratory subjects with a variety of measurements (ref. 1).

Analysis of data from this optimizer has shown that significant reductions in noise may be obtained with trajectory optimization. And since throttling operations are performed in the subsonic portion of the climb path (where thrust is plentiful), only small penalties in HSCT range or fuel performance occur.

Reference

1. McCurdy, D.A.: Annoyance Caused by Aircraft En Route Noise. NASA TP-3165, 1992.

Lewis contact: Jeffrey J. Berton, (216) 977-7031, Jeffrey.J.Berton@grc.nasa.gov

Author: Jeffrey J. Berton

Headquarters program office: OASTT

Programs/Projects: HSR